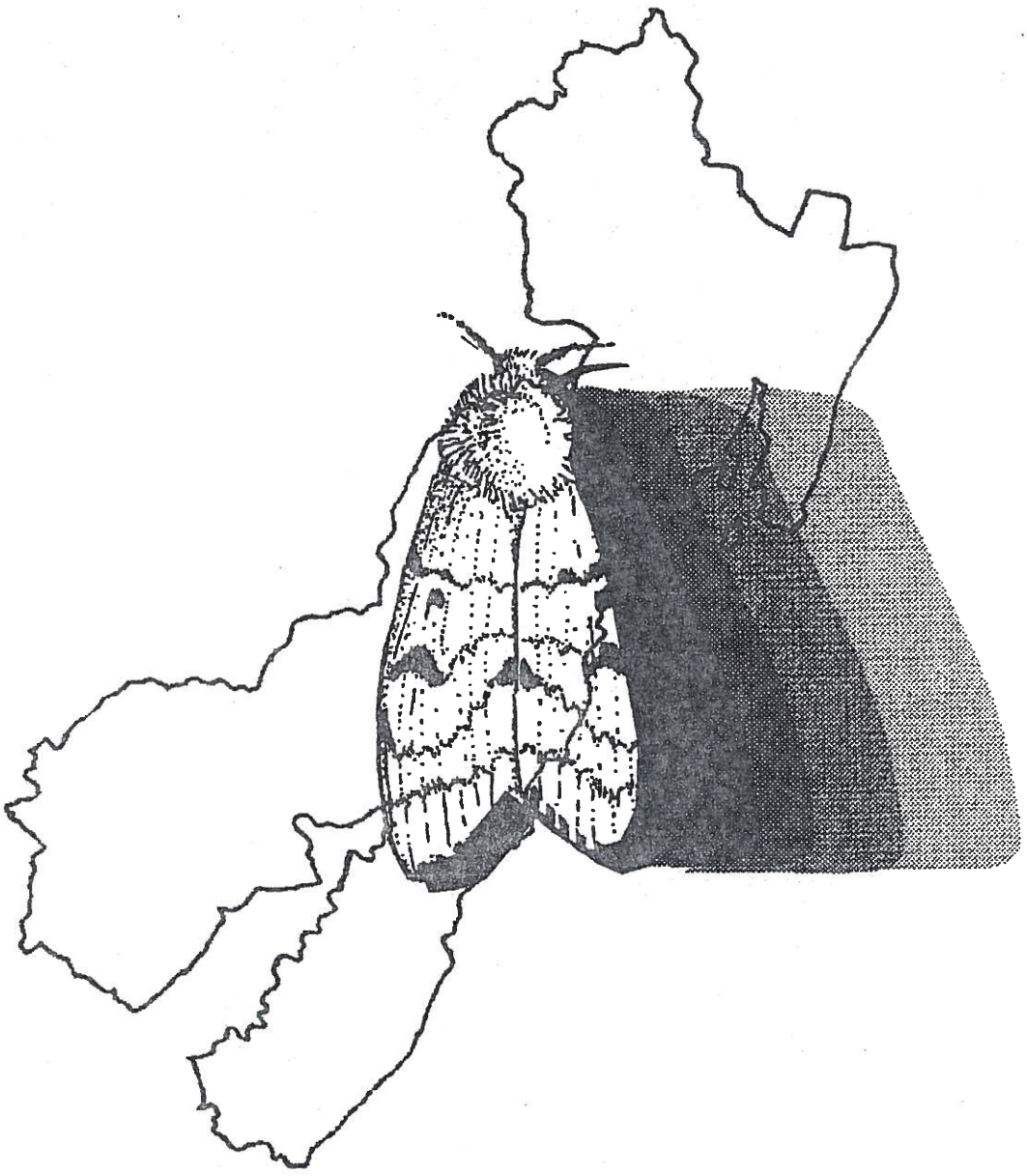
History of Gypsy Moth Management on the Monongahela National Forest 1993 - 1995



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Summary

A total of 32,596 acres of forest land that contained high-density gypsy moth populations have been aerially treated with biological insecticides to protect foliage and suppress populations on the Monongahela National Forest (MNF) from 1993 to 1995. *Bacillus thuringiensis* var. *kurstaki* (*Btk*) as undiluted Foray 48B was applied to 17,425 acres (53 percent of the total). The MNF responded to environmental concerns for Threatened and Endangered Species and non-target Lepidoptera by treating the remaining 15,171 acres (47 percent of the total) with the gypsy moth specific nucleopolyhedrosis virus product, Gypchek or Entotech. The Gypchek spraying was the largest operational use of this insecticide by the US Forest Service to date.

Proposed treatment areas on the MNF were delineated based on gypsy moth egg mass surveys in areas where defoliation had been detected. Egg mass surveys were conducted in each spray block before and after treatment using the 1/40th fixed-radius plot method. Defoliation was delineated using either aerial sketch maps or ground visits.

Spray aircraft navigation technology improved during the MNF suppression projects. During 1993 and 1994, visual navigation using topographic maps was accompanied by radio communication from aerial observation aircraft and ground personnel. However in 1995, spray contract specifications required that Differential Global Positioning System (DGPS) be used during aerial application of all treatment blocks for precise navigation and flight recording. Each spray aircraft was equipped with a DGPS system. This was the first year DGPS was used operationally on the MNF suppression project.

The success of the MNF gypsy moth suppression projects were based on: 1) protecting the forest canopy by preventing defoliation from reaching 30 percent, and; 2) reducing gypsy moth populations so that re-treatment the following year would not be necessary. Annual project success expressed in terms of foliage protection and population reduction on the acres sprayed with each formulation for the year shown are listed in the table below.

Biological Insecticide Specifications					Results	
Year	**Acres**	**Formulation**	**Dose**	**Applic. Rate**	**Forest Canopy Prot.**	**Pop. Reduction**
1993	7,276	Foray 48B	36 BIU/ac	96 oz/ac	100%	100%
1993	2,725	Gypchek	2×10^{11} OBs/ac	64 oz/ac*	57%	10%
1994	2,509	Foray 48B	36 BIU/ac	96 oz/ac	100%	100%
1994	4,915	Entotech 244	2×10^{11} OBs/ac	128 oz/ac*	100%	73%
1995	14,189	Foray 48B	36 BIU/ac	96 oz/ac	100%	98%
1995	982	Entotech 038	2×10^{11} OBs/ac	128 oz/ac*	100%	100%
Total	**32,596**					

*double application

Btk treatments consistently achieved the highest success while NPV treatment efficacy improved each year. However, all results in 1995 were confounded by significant larval mortality caused by the gypsy moth fungus *Entomophaga maimaiga* and naturally occurring gypsy moth nucleopolyhedrosis virus (NPV) in treated and untreated areas. It is possible that treatment success could be attributed to a combination of treatment efficacy and epizootics.

Based on results from the 1993-1995 MNF suppression projects, the following recommendations were made for any future gypsy moth suppression projects: 1) *Btk* at 36 BIU/ac; (2) Double application of Carrier 038 + Gypchek at 2×10^{11} OBs/Ac at the application rate of 128 ounces per acre in environmentally sensitive areas with Threatened and Endangered Species or non-target Lepidoptera of special concern; 3) Monitor gypsy moth populations in unsprayed areas adjacent to spray blocks as well as in spray blocks, and; 4) Sample dead gypsy moth larvae for laboratory analysis of *Entomophaga maimaiga* and NPV to account for the influence of these two important natural control factors on gypsy moth populations.

Introduction

Gypsy moth management on lands within the Monongahela National Forest (MNF) proclamation boundary was under the jurisdiction of the Appalachian Integrated Pest Management (AIPM) Project from 1987 until September 30,1992. Gypsy moth populations during this period began to increase on the MNF. Gypsy moth management for the MNF during the AIPM project was designed for intervention tactics to prevent first time defoliation and slow the spread of concentrated low density gypsy moth populations.

Gypsy moth management for the MNF starting in 1993 shifted from intervention tactics to direct treatment by aerial spraying. This tactic was employed to prevent unacceptable damage to forest resources from concentrated high density gypsy moth populations within areas where defoliation had occurred previously. Treatment were conducted to: 1) prevent nuisance, aesthetic loss and human health hazards in developed recreation areas; 2) reduce tree mortality and maintain wildlife habitats where management goals emphasized timber and wildlife; 3) enhance visual quality for dispersed recreation; and, 4) promote biodiversity by protecting unique forest habitats. Gypsy moth management is currently the responsibility of the MNF Forest Supervisor with technical assistance and funding provided by Forest Health Protection in Morgantown. This report provides a history of gypsy moth management on the MNF from 1993 to 1995 with the biological insecticides *Bacillus thuringiensis* var. *kurstaki* (*Btk*) applied as undiluted Foray 48B and the gypsy moth nucleopolyhedrosis virus (NPV) as Gypchek or Entotech.

Gypsy Moth Management On The Monongahela National Forest From 1993-1995

Pre-treatment Block Selection

Proposed treatment areas on the MNF were delineated based on gypsy moth egg mass surveys. The 1/40th acre fixed-radius plot method was used in the fall of each year where defoliation had been detected and mapped earlier in the summer. Additional parts of the MNF, which in earlier years were known to have low density gypsy moth populations, were also surveyed for egg masses to locate possible building populations.

Post-treatment Surveys

Gypsy moth egg mass surveys were conducted in each spray block the fall after treatment using the 1/40th acre fixed-radius plot method. Defoliation was delineated using either aerial sketch map surveys or ground visits to the blocks during peak defoliation which is usually the month of July following spraying. The defoliation was categorized as none, light (1-30 percent of the foliage missing), moderate (31-60 percent of the foliage missing), and heavy (61-100 percent of foliage missing).

Treatment Monitoring

The MNF is included into the Gypsy Moth Treatment Monitoring Program as required by Forest Health Protection. The objective of the Treatment Monitoring Program is to evaluate the success of a suppression project based on project objectives and treatment thresholds stated in the Environmental Assessment for gypsy moth suppression projects in Federal and State forests.

Treatment Success Criteria

Project success each year were based on the percentage of acres within the spray blocks that meet project objectives. The project objectives of forest canopy protection and population reduction were predetermined thresholds established for each set of management objectives.

Project Objectives

The MNF gypsy moth suppression project objectives and treatment thresholds from 1993 through 1995 were: (1) protect the forest canopy by preventing defoliation from reaching 30 percent; (2) reduce gypsy moth populations below the treatment decision threshold density of 250 egg masses/acre in treatment units within developed recreation areas; and (3) reduce gypsy moth populations to 500 egg masses/acre or less in treatment units with timber, wildlife, watershed and dispersed recreational values.

1993 Gypsy Moth Suppression Project

In 1993, the MNF treated 16 blocks totaling 12,726 acres in Grant and Pendleton Counties located on the Potomac Ranger District. Nine of the 16 blocks treated in 1993 had been treated in 1992 under AIPM. Five blocks were treated with a double application of the Gypchek tank mix at the application rate of 64 ounces per acre. The tank mix consisted of Lignosite AN (10% wt/vol), Pro-Mo (25% vol/vol), Bond spreader sticker (2% vol/vol), and Gypchek at 2 x 10^{11} OBs/Ac. Eleven blocks were treated with a single application of undiluted Foray 48B at 36 BIU/ac at the application rate of 96 ounces per acre. Two piston Ag-Cat spray aircraft each equipped with Hi-Tek nozzles, were calibrated to deliver 64 or 96 ounces per acre over a 100 foot swath. Treatments began on May 8th when the average expansion of foliage was 30-75% and a majority of gypsy moth larvae were in the late first and early second instars. The last block was treated on May 17th when the average expansion of foliage was 70-90% and a majority of larvae were second instar.

1 1/2 GAL/AC

Results and Discussion

Forest Canopy Protection

No defoliation was found in the blocks treated with Foray 48B. Three of the five blocks treated with Gypchek received greater than 30 percent defoliation (see table 1). The acreage that was treated successfully with Gypchek represent 57% of the total acreage treated.

Table 1. Defoliation of treatment blocks in the 1993 Gypsy Moth Project, Monongahela National Forest

		Defoliation Categories (Acres)			
Block	Acres	None	Light (1-30%)	Moderate (31-60%)	Formulation
301	466	466	0	0	Foray 48B
302	1,048	1,048	0	0	Foray 48B
303	1,752	1,752	0	0	Foray 48B
312	567	567	0	0	Foray 48B
304	298	298	0	0	Foray 48B
305	646	646	0	0	Foray 48B
308	330	330	0	0	Foray 48B
309	181	181	0	0	Foray 48B
310	960	960	0	0	Foray 48B
313	712	712	0	0	Foray 48B
317	316	316	0	0	Foray 48B
Subtotal	**7,276**	**7,276**	**0**	**0**	**Foray 48B**

Table 1. Continued

Block	Acres	Defoliation Categories (Acres) None	Light (1-30%)	Moderate (31-60%)	Formulation
307	636	636	0	0	Gypchek
306	269	269	0	0	Gypchek
311	985	98	0	887	Gypchek
314	351	211	0	140	Gypchek
315	484	339	48	97	Gypchek
Subtotal	**2,725**	**1,553**	**48**	**1,124**	Gypchek
Total	**10,001**	**8,829**	**48**	**1,124**	**Gypchek**

Gypsy Moth Population Reduction

Table 2 gives block information and average egg mass densities before and after treatment from the 16 blocks constituting the 1993 project.

Table 2. Egg mass densities before and after treatment in the 1993 Gypsy Moth Project, Monongahela National Forest

Block	Acres	Pre-Treatment (Em/Ac)	Post-Treatment (Em/Ac)	% Reduction[1]	Formulation
301	466	11,068	36	99	Foray 48B
302	1,048	2,184	21	99	Foray 48B
303	1,752	781	4	99	Foray 48B
312	567	978	40	96	Foray 48B
304	298	1,096	6	99	Foray 48B
305	646	1,616	75	95	Foray 48B
308	330	763	0	100	Foray 48B
309	181	1,440	12	99	Foray 48B
310	960	1,006	8	99	Foray 48B
313	712	1,445	40	99	Foray 48B
317	316	947	68	93	Foray 48B
Subtotal	**7,276**				**Foray 48B**
307	636	925	774	16	Gypchek
306	269	3,057	184	94	Gypchek
311	985	1,653	1,116	33	Gypchek
314	351	1,247	1,315	-5	Gypchek
315	484	958	617	36	Gypchek
Subtotal	**2,725**				**Gypchek**
Total	**10,001**				

[1]% Reduction = $\frac{\text{(Pre-Treatment - Post-Treatment)}}{\text{Pre-Treatment}} \times 100$

Based on MNF's objective of reducing gypsy moth populations to less than 250 egg masses/acre for developed recreational areas and 500 egg masses/acre for areas with timber, wildlife, watershed and developed recreational values, 100 percent of the blocks treated with Foray 48B were successfully treated. Results with Gypchek were inconsistent compared to blocks treated with Foray 48B. Residual gypsy moth populations remained above the treatment decision threshold in four of the Gypchek blocks, all of which were considered for re-treatment in 1994.

The Gypchek block that was treated successfully (Block 306) represents 10% of the acreage treated.

Efficacy of Spray Microbials

According to the MNF's treatment objectives, 100 percent of the blocks treated with undiluted Foray 48B were successfully treated based on population reduction and foliage protection. The success rate for the Gypchek blocks were not as good. One of the five blocks was treated successfully based on population reduction and two blocks were treated successfully based on foliage protection.

The success of the aerial application of higher doses of undiluted Foray 48B at 36 BIU/ac compared with Gypchek is apparent. However, there were localized population collapses in sections of the project area which almost certainly influenced the project results. One of the factors possibly involved in these local collapses was the gypsy moth fungus *Entomophaga maimaiga.* According to field personnel, dead gypsy moth larvae exhibited the physical characteristics of fungus-killed cadavers (withered and brittle, frequently attached to boles of trees vertically with heads downward and abdominal prolegs at a 90 degree angle to the body) during July 1993 in the northernmost blocks treated with Foray 48B.

The failure of the four Gypchek spray blocks to meet MNF efficacy standards for residual gypsy moth populations lead the MNF to propose these same forested areas as high priority for re-treatment in 1994. The exact cause of the failure is unknown. The lower spray volume and dose of Gypchek per application compared to previous years could be a contributing factor. In previous years the prescription for maximum efficacy when using Gypchek was two applications, three days apart at 5×10^{11} OBs at an application rate of 2 gallons per acre. With a goal of reducing per acre treatment costs, a reduced dosage and volume treatment (2×10^{11} OBs in 0.5 gallons per acre, twice) was field tested in Virginia (Podgwaite, J. D. and R. C. Reardon. 1991. pp. 115-116 *In* Proc. 1991 Annual Gypsy Moth Review) and in Ontario (Cunningham, J. C. et al. 1991. pp. 108-114 *In* Proc. 1991 Annual Gypsy Moth Review) in 1991. Both tests indicated that the treatment was efficacious. In 1992, the low dosage and low volume was pilot tested in Pennsylvania and Ontario and based upon results, the reduced dosage/volume prescription was recommended for operational use on the MNF in 1993.

Gypsy Moth Treatment Monitoring Database revealed three plausible reasons for the high failure rate of the Gypchek blocks: 1) the first operational use of the reduced dosage/volume may not have been as efficacious as 1991 and 1992 research results predicted; 2) two of the blocks received the second application 5 days after the first application; and 3) Block 214 was treated with winds recorded at 10 mph.

1994 Gypsy Moth Suppression Project

In 1994, the MNF treated 13 blocks totaling 7,424 acres in Tucker, Grant and Pendleton Counties located on the Cheat and Potomac Ranger Districts. Sixty-six percent (4,915 acres) of the spray project area was treated with Gypchek due to environmental considerations for the Virginia Big Eared Bat foraging areas and non-target moths of special concern to the West Virginia Department of Natural Resources Natural Heritage Program. This represented the largest operational use of Gypchek to date. Three of the 13 blocks (Blocks 501, 507, and 510) had been treated in 1993. In 1994, eight blocks were treated with a double application of the Entotech Carrier 244 + Gypchek at 2×10^{11} OBs/Ac at the application rate of 128 ounces per acre. Five blocks were treated with a single application of undiluted Foray 48B at 36 BIU/ac at the application rate of 96 ounces per acre. Two piston Ag-Cat spray aircraft each equipped with Hi-Tek nozzles and a Dromader M18 equipped with Flat Fan nozzles were calibrated to deliver 128 and 96 ounces per acre over a 100 foot swath. Treatments began on May 3rd when the average expansion of foliage was 30-60% and a majority of gypsy moth larvae were in the late

first and early second instars. The last block was treated on May 14th when the average expansion of foliage was 40% and a majority of larvae were in the late first instar.

Results and Discussion

Forest Canopy Protection

No defoliation was found in the blocks treated with either Foray 48B or Gypchek.

Gypsy Moth Population Reduction

Table 3 gives block information and average egg mass densities before and after treatment from the 13 blocks constituting the 1994 project.

Table 3. Egg mass densities before and after treatment in the 1994 Gypsy Moth Project, Monongahela National Forest

Block	Acres	Pre-Treatment (Em/Ac)	Post-Treatment (Em/Ac)	% Reduction[1]	Formulation
507	400	1228	400	67	Foray 48B
508	487	1900	40	98	Foray 48B
509	766	1589	40	97	Foray 48B
101	156	184	0	100	Foray 48B
102	700	254	80	69	Foray 48B
Subtotal	**2,509**				**Foray 48B**
501	632	1063	0	100	Gypchek
502	1,557	1038	40	96	Gypchek
503	73	670	80	88	Gypchek
504	164	1175	40	97	Gypchek
505	1,310	1358	440	68	Gypchek
506	300	1550	60	96	Gypchek
510	399	617	80	87	Gypchek
7507	480	1228	40	97	Gypchek
Subtotal	**4,915**				**Gypchek**
Total	**7,424**				

[1]% Reduction = $\frac{\text{(Pre-Treatment - Post-Treatment)}}{\text{Pre-Treatment}} \times 100$

Based on MNF's objective of reducing gypsy moth populations to less than 250 egg masses/acre for developed recreational areas and 500 egg masses/acre for areas with timber, wildlife, watershed and developed recreational values, 100 percent of the blocks treated with Foray 48B were successfully treated. Seven of the eight Gypchek spray blocks had post-treatment gypsy moth egg mass densities substantially below treatment decision thresholds. Spray block 505 which is a popular game hunting area had a post-treatment egg mass density above the 250 egg masses per acre threshold. Residual gypsy moth populations remained above the treatment decision threshold and was given priority for re-treatment in 1995..

Efficacy of Spray Microbials

According to the MNF's treatment objectives, 100 percent of the blocks treated with Foray 48B were successfully treated based on population reduction and foliage protection. The success rate for the Gypchek blocks were 100 percent based on foliage protection and 73 percent based on population reduction.

The failure of Gypchek spray block 505 to meet MNF efficacy standards for residual gypsy moth populations lead the MNF to propose the same forested areas for re-treatment in 1995. The exact cause of the failure is unknown. The dose of Gypchek used per application was the same as in 1993 but a higher volume (128 oz/ac vs. 64 oz/ac). The Entotech Carrier 244 used in 1994 was slightly modified from the Carrier 244 used in 1993. The "modified" Carrier 244 caused sedimentation in the bottom of the 55 gallon barrels and each barrel had to be stirred prior to mixing the Gypchek. The pilots also noted that the Carrier was hard on their pump seals and could have caused leaking and inconsistent flow rates. In 1994, the same dosage, volume and "modified" Carrier used on the MNF was pilot tested in Virginia. Based on results from replicated treatment blocks, all treatments failed compared to the results from the control blocks (Onken, A. 1996 Thesis). Even though results from this test were severely compromised (first application was too late based on insect and foliage development and rain delayed the second application), according laboratory evaluations, the "modified" Carrier did not inhibit the efficacy of Gypchek (Reardon, R. C., personal communication and Onken, A. 1996 Thesis). The "modified" Carrier caused problems during mixing but the results based on population reduction and foliage protection are better than results reported in 1993.

We believe therefore, the failure rate of Gypchek block 505 can be attributed to two factors: 1) due to rain, the block received the second application 6 days after the first application; and 2) the block received more than a 1/2" of rain after the first application. However, it should be noted that three blocks (501, 503 and 510) also received the second application 6-7 days after the first application and more than 1/2" rain after either the first or second application. The blocks were successfully treated based on population reduction and foliage protection but these blocks had the lowest pre-treatment egg mass densities compared to the other Gypchek blocks.

1995 Gypsy Moth Suppression Project

In 1995, the MNF treated 17 blocks totaling 15,171 acres in the Cheat, Greenbrier, and Potomac Ranger Districts. One of the 17 blocks treated in 1995 had been treated in 1994. In 1995, three blocks were treated with a double application of the Entotech Carrier 038 + Gypchek at 2×10^{11} OBs/ac at the application rate of 128 ounces per acre, eight blocks were treated with a single application of Foray 48B at 36 BIU/ac at the application rate of 96 ounces per acre, and six blocks were treated with a double application of Foray 48B at 24 BIU/ac at the application rate of 64 ounces per acre. Two Ayers Thrush spray aircraft each equipped with 8004 nozzles were calibrated and characterized to deliver 64, 96 and 128 ounces per acre over a 100-foot swath. Both aircraft were equipped with a DGPS system (AGNAV) and all blocks were treated using DGPS. Treatments began on May 7th when the average expansion of foliage was 25-30% and a majority of gypsy moth larvae were in the first instar. The last blocks were treated on June 4th when the average expansion of foliage was 100% and a majority of larvae were in the second and third instars. Adverse weather conditions (wind and rain) delayed applications on several of the blocks.

Results and Discussion

Forest Canopy Protection

No defoliation was found in the blocks treated with either Foray 48B or Gypchek.

Gypsy Moth Population Reduction

Table 4 gives block information and average egg mass densities before and after treatment from the 17 blocks constituting the 1995 project.

Table 4. Egg mass densities before and after treatment in the 1995 Gypsy Moth Project, Monongahela National Forest

Block	Acres	Pre-Treatment (Em/Ac)	Post-Treatment (Em/Ac)	% Reduction[1]	Formulation
501	205	970	0	100	Gypchek
502	138	1973	0	100	Gypchek
503	639	760	48	94	Gypchek
Subtotal	**982**				**Gypchek**
301	643	762	0	100	Foray 48B[2]
109	597	993	0	100	Foray 48B[2]
110	1092	1295	148	89	Foray 48B[2]
101	2197	4478	0	100	Foray 48B[3]
102	375	480	0	100	Foray 48B[2]
103	1619	3914	0	100	Foray 48B[3]
104	914	4400	60	99	Foray 48B[3]
105	847	847	0	100	Foray 48B[3]
106	1507	3213	48	99	Foray 48B[3]
107	1563	2796	0	100	Foray 48B[2]
108	2008	2590	76	97	Foray 48B[3]
111	146	1813	0	100	Foray 48B[2]
112	425	2116	56	97	Foray 48B[2]
113	256	676	256	62	Foray 48B[2]
Subtotal	**14,189**				**Foray 48B**
Total	**15,171**				

[1] % Reduction = $\frac{(\text{PreTrt} - \text{PostTrt})}{\text{PreTrt}} \times 100$

[2]One application at 36 BIU at the application rate of 96 ounces/acre
[3]Two applications at 24 BIU at the application rate of 64 ounces/acre

Based on MNF's objective of reducing gypsy moth populations to less than 250 egg masses/acre for developed recreational areas and 500 egg masses/acre for areas with timber, wildlife, watershed and developed recreational values, 100 percent of the blocks treated with Gypchek were successful. Fourteen of the fifteen Foray 48B spray blocks had post-treatment gypsy moth egg mass densities substantially below treatment decision thresholds. Spray block 113 which is considered a "high recreational value area" did not meet the post treatment criteria of 250 egg masses/acre or less by a narrow margin.

Efficacy Of Spray Microbials

According to the MNF's treatment objectives, 100 percent of the blocks treated with Gypchek successfully achieved population reduction and foliage protection. The success rate for the Foray 48B blocks were 100 percent based on foliage protection and 98 percent based on population reduction. It should be noted that the post-treatment egg mass density for the block 113 marginally failed with 256 egg masses per acre, only 6 egg masses per acre above the treatment threshold of 250 egg masses/acre.

Many natural diseases caused by bacteria, fungi, and viruses affect the gypsy moth, especially when its populations are at outbreak densities and compete for a limited food source. Significant larval mortality caused by the gypsy moth fungus *Entomophaga maimaiga* and the nucleopolyhedrosis virus (NPV) occurred in treated and untreated areas. It was also reported that some areas surrounding treatment blocks received varying degrees of defoliation. In these areas, very few egg masses were found and cadavers were collected and identified as being

killed by either NPV or *E. maimaiga*. It is possible that treatment success could be attributed to a combination of treatment efficacy and epizootics.

Three-Year Summary Of Gypsy Moth Suppression Projects

The objectives of the MNF gypsy moth suppression projects were: (1) protect the forest canopy by preventing defoliation from reaching 30 percent; (2) reduce gypsy moth populations below treatment thresholds to 250 egg masses/acre or less in treatment units within developed recreation areas; and (3) reduce gypsy moth populations to 500 egg masses/acre or less in treatment units with timber, wildlife, watershed and dispersed recreational values. These treatment objectives were evaluated by aerial and ground defoliation surveys and post-treatment egg mass surveys, respectively. Table 5 summarizes the annual gypsy moth treatments and project success expressed in terms of foliage protection and population reduction on the acres sprayed with each formulation for the year shown.

Table 5. Summary of Results of Gypsy Moth Suppression Projects on the Monongahela National Forest, 1993-1995

Biological Insecticide Information			**Results**	
Treatment Year	**Formulation**	**Acres**	**Forest Canopy Protection**	**Population Reduction**
1993	Foray 48B	7,276	100% Success	100% Success
1993	Gypchek	2,725	57% Success	10% Success
1994	Foray 48B	2,509	100% Success	100% Success
1994	Gypchek	4,915	100% Success	73% Success
1995	Foray 48B	14,189	100% Success	98% Success
1995	Gypchek	982	100% Success	100% Success
Total		**32,596**		

Conclusions

The decision by the MNF to apply undiluted *Btk* at 36 BIU/ac appears to be supported by inconsistent results from several recent State Cooperative Gypsy Moth Suppression Projects which used lower doses and results from earlier efficacy research with *Btk.* With the treatment success criterion of a residual population in treated areas below the threshold for re-treatment the following year, Ohio, Delaware, and Maryland reported a 31, 34, and 74 percent success rate, respectively (1995 TMDB). In 1995, New Jersey reported a 86 percent success rate using *Btk* at 30 BIU/ac (1995 TMDB). Research in 1989 by Dubois et al. (1993) compared the efficacy of three doses of *Btk* . All treatments significantly reduced the population and protected foliage. At 36 BIU/ac, the pest population was consistently reduced (five replicates out of five) to less than 50 egg masses per acre. Though the mean population reduction at doses of 12 BIU/ac and 24 BIU/ac did not differ significantly from that of 36 BIU/ac, they were not as consistent; i.e., only one or two replicates out of five were reduced to less than 50 egg masses per acre. Based on the results from 1993-1995 MNF suppression project and previous studies, *Btk* at 36 BIU/ac should be recommended for any future gypsy moth suppression projects.

With the exception of 1993 when Gypchek was applied at a lower dose and lower volume than in previous years, Gypchek has been fairly successful in population reduction and excellent for foliage protection. Based on the 1995 treatment efficacy, the results support the current Forest Service recommendation that a double application of Carrier 038 + Gypchek at one gallon of formulation and 2×10^{11} OBs/ac per application will provide gypsy moth control. This dose and volume should be recommended for future gypsy moth suppression projects in areas that contain Federally listed Threatened and Endangered species or non-target moths of special concern.

Results from 1995 show the highest success rate for both Gypchek and Foray 48B. The high success rate can be attributed to three factors: 1) treatment efficacy; 2) 1995 was the first year DGPS was used; and 3) significant larval mortality due to *Entomophaga maimaiga* and NPV was recorded in some treatment blocks and areas surrounding the treatment blocks. It is possible that treatment success could be attributed to a combination of all three factors.

Evaluating gypsy moth suppression project treatment efficacy requires taking into account two important natural control factors affecting gypsy moth populations. To determine their influence in future suppression projects, spray blocks and unsprayed areas adjacent to spray blocks should be surveyed. A survey should be planned to sample gypsy moth egg mass densities (pre- and post-treatment) and dead larvae within each spray block for laboratory analysis to determine the presence and abundance of *Entomophaga maimaiga* and NPV.

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